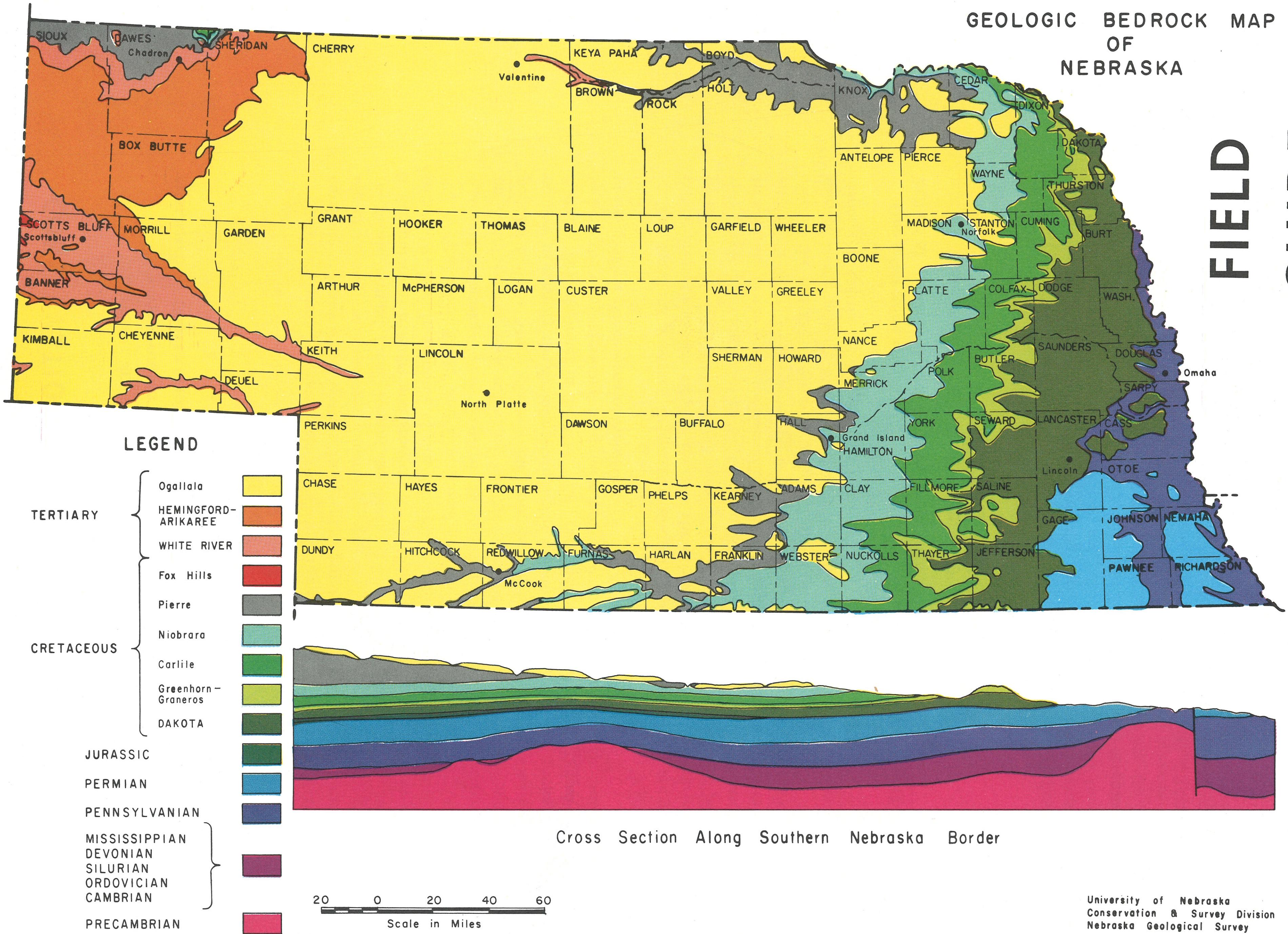
1977

Jefferson County , Fairbury Area

R. K. Pabian
University of Nebraska - Lincoln

FIELD GUIDE

GEOLOGIC BEDROCK MAP OF NEBRASKA



Cross Section Along Southern Nebraska Border

University of Nebraska
Conservation & Survey Division
Nebraska Geological Survey
1969

NOTE: Unconsolidated sediments of Pleistocene age cover the bedrock throughout much of the State and are not shown.

THE UNIVERSITY OF NEBRASKA
CONSERVATION AND SURVEY DIVISION

GEOLOGICAL SURVEY — SOIL SURVEY

WATER SURVEY — INFORMATION SURVEY

PUBLISHED IN COOPERATION WITH: NEBRASKA GEOLOGICAL SOCIETY
LINCOLN GEM & MINERAL CLUB

PREFACE

In recent years the earth sciences have become an important part of the curricula of many school systems. In the past, pupils were given only a smattering of geology, paleontology, mineralogy, etc. to help them better understand the world around them. Recent emphasis on the earth sciences has created a demand from teachers and students for geologic information in the area in which they live. In response to this demand in Nebraska, Educational Circular No. 1, "Record in Rock," and Educational Circular No. 2, "Minerals and Gemstones of Nebraska," were prepared. In addition to the educational emphasis on earth sciences, rock collecting has grown to be one of the nation's most popular hobbies. Many students and hobbyists are now requesting information on how to identify the various stratigraphic horizons (rock layers) and geologic features they encounter in the field. Thus, these field guides have been prepared to help the nonprofessional familiarize himself with the stratigraphy and some of the geologic phenomena of Nebraska.

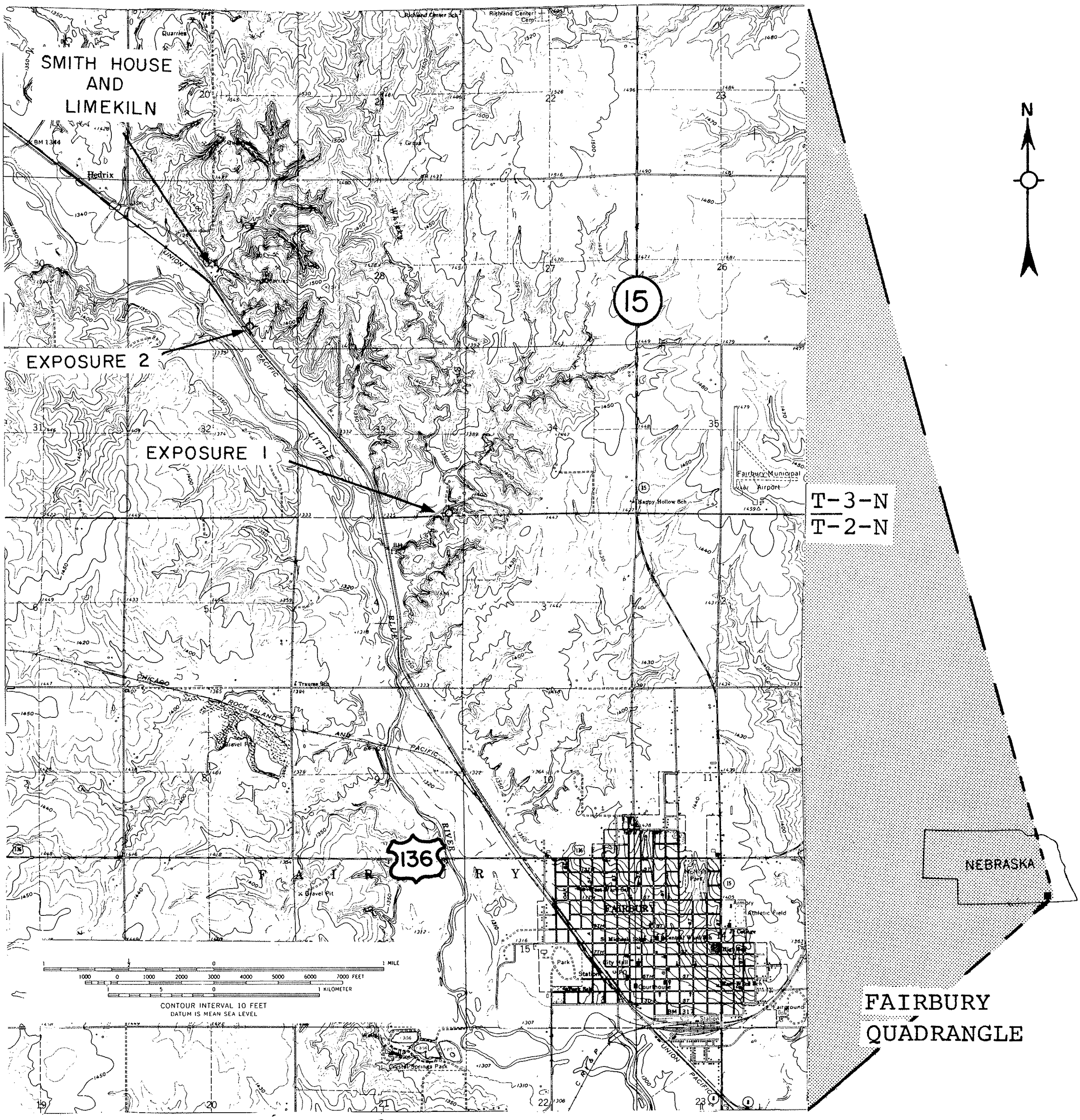
The locations presented herein were chosen for several reasons. All are on public property so that viewing them is always possible. All are easily reached by car and are generally accessible even to the elderly or handicapped. All provide "typical" examples of either common Nebraska rocks, minerals, or fossils. In addition to the brief description of the stratigraphy and the rocks, minerals, and fossils found in the outcrops, a brief description of the land forms within view of the outcrop is given. It is hoped that this information will orient the student to the geology of Nebraska and help him to understand the processes responsible for the landscape about him.

One safety note: when visiting these outcrops, be sure that your car is parked well off of the road—if your car is equipped with safety blinkers, use them.

The Conservation and Survey Division of the University is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources.

The Division is authorized to enter into agreements with federal agencies to engage in cooperative surveys and investigations in the state. Publications of the Division and the cooperating agencies are available from the Conservation and Survey Division, University of Nebraska, Lincoln 68508.

Publication and price lists are furnished upon request.



LOCATIONS AND ELEVATIONS OF EXPOSURES
NORTH OF FAIRBURY

Figure 1

Exposure 1 is located in the SE ¼, SE ¼, sec. 33, T-3-N., R-2-E. The elevation at the adjacent road grade is 1,350 feet above sea level.

Exposure 2 is located in the SW ¼, SE ¼, sec. 29, T-3-N, R-2-E. The elevation at the adjacent road grade is 1,350 feet above sea level.

The Smith House and Limekiln are located in the center of sec. 29, T-3-N, R-2-E. The elevation at the adjacent road grade is 1,350 feet above sea level. Locations of exposures 3-7 are shown in figure 6.

EXPOSURES NEAR FAIRBURY, NEBRASKA

Several outcrops of Cretaceous rocks near Fairbury, Jefferson County, reveal an interesting chapter of geologic history. You can observe in this sequence of layered rocks the changes that occur when a land area is covered by a slowly advancing sea. These rock layers record a sea advancing in Cretaceous time (see back cover). Abundant plant remains in one sequence of rocks (exposure 1) have been transformed into peat and lignite coal. Geologists classify the sedimentary rock sequence described herein as belonging to the Cretaceous; the Dakota Group (exposures 1-6) and the Graneros Shale-Greenhorn Limestone Formations (exposure 7).

HOW TO FIND THE EXPOSURES

Exposure 1

Use a Nebraska highway map to proceed from your starting point to the junction of State Highway 15 and U. S. Highway 136, in the northeast part of Fairbury. Proceed north on Highway 15 for 2.2 miles; turn west (left) onto the county road and proceed one mile to the abandoned gravel pit. Note the large quartzite boulders. Called "erratics," these were transported to Nebraska from Minnesota and South Dakota by glaciers during the Ice Age (Pleistocene).

Continue westward along the county road for 0.1 mile to the large shale exposure on your left (exposure 1). These shales are part of the Dakota Group. Notice the repetition of similar beds in the sequence (figure 2). Repeated cycles of deposits are commonly seen in sedimentary rocks. The yellow-brown layers are sandy shales; the very dark gray layers are carbonaceous shales; the black layers are peat or lignite coal. You may find some lignite coal and an occasional leaf imprint here.

Exposure 2

Proceed westward along the county road for 0.4 mile; turn northwest (right) at the "T" intersection where the road ends and one must turn right or left. Proceed for 1.4 miles. Notice the large exposure of sandstone and shale to your right. These deposits were laid down by a river during Cretaceous time.

The mystified braves in figure 3 are wondering what happened to the river. They got there a few years too late (about 90,000,000) for their canoe trip. If they had been here in Cretaceous (Dakota time) their canoe trip would have been more timely, for then they would have had a river to navigate. The

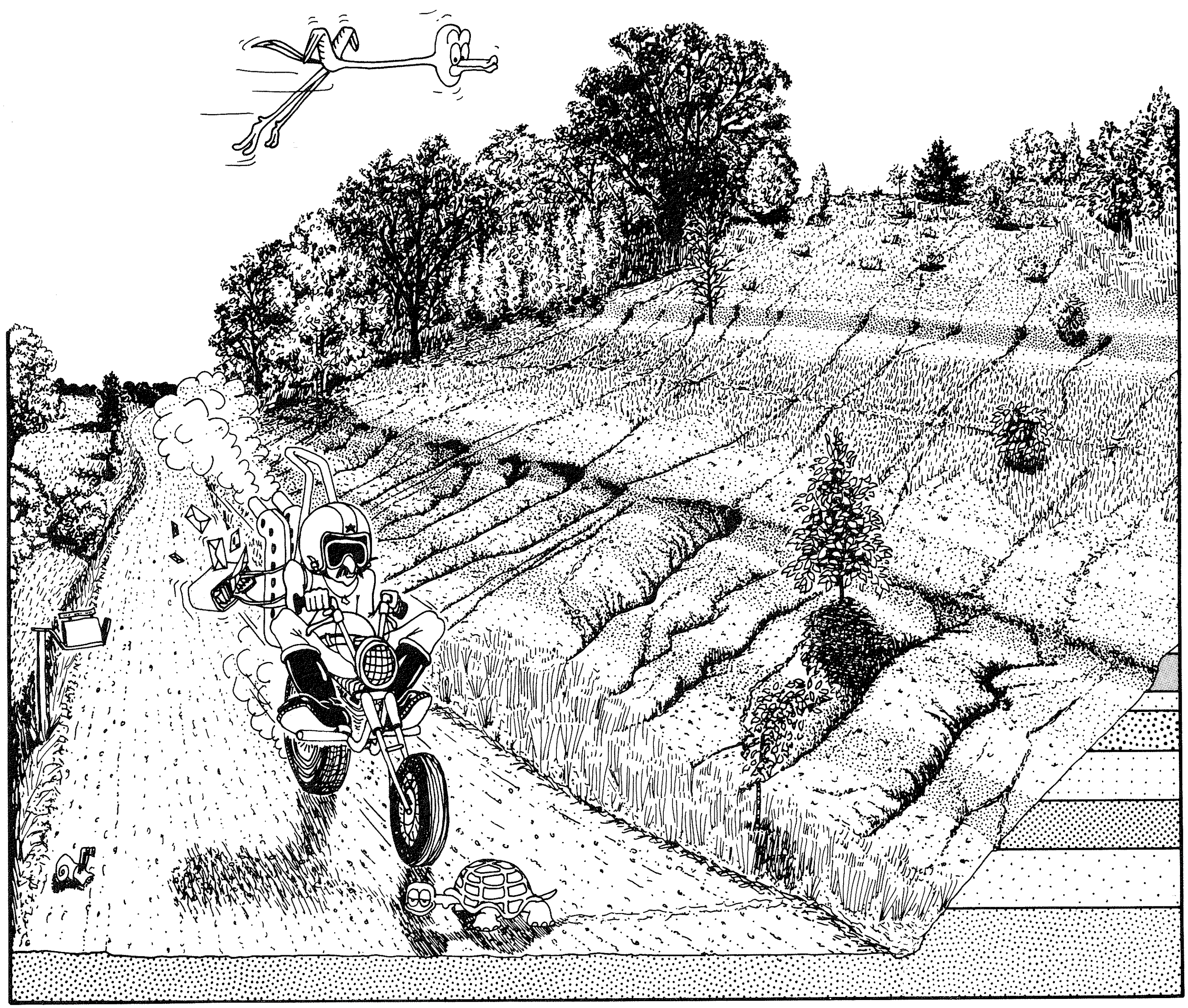


Figure 2.--Idealized section at exposure 1. Note that slumping may alter the appearance of the exposure. View looking east.

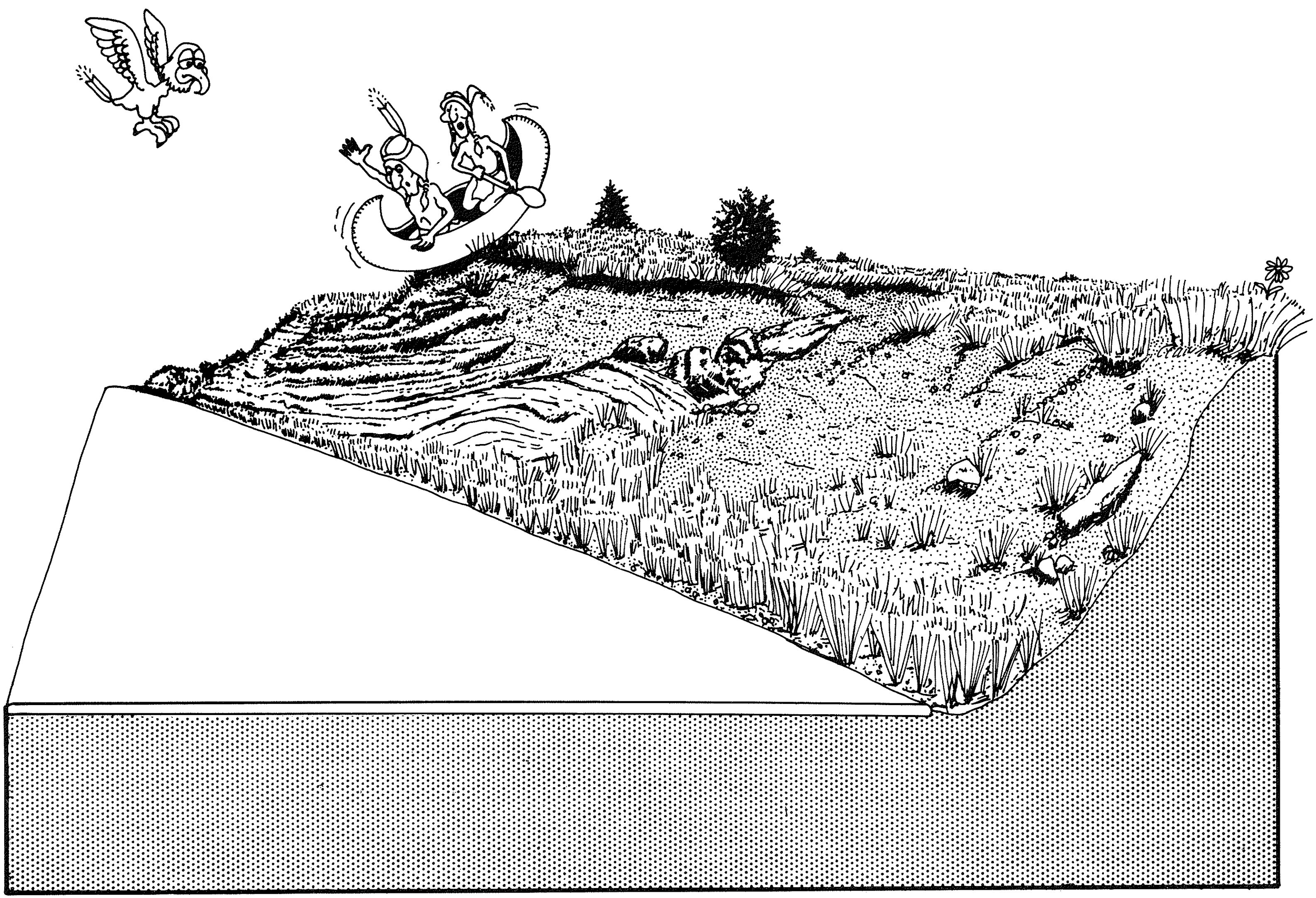


Figure 3.--Idealized section at exposure 2. Note that slumping may alter the appearance of the exposure. View looking northwest.

nature of the sandstone beds tells us that they were deposited by a river. However, the fossil river channel that once was in a valley is now occupying a highland. The channel sands became lithified (grains cemented together) to form sandstone. The softer surrounding rock was eroded so that the remnants of the channel now form a topographic high. Dipping (nonhorizontal) beds and cross-bedding (discussed later) in the sandstone body are evidence of stream deposits.

Notice the shale tongues extending into the outcrop from either end. This shale was originally deposited as silts and clays on the flood plain of the ancient stream; the sands represent the channel deposits of the stream. Such an outcrop as seen at exposure 2 has a very complex geological history, which is illustrated in figure 4.

SMITH HOUSE AND LIMEKILN

Proceed westward 0.3 mile. To your right you can see the Smith House and Limekiln (figures 5a, 5b). Mortar was once produced in the Smith Limekiln by roasting impure limestone and pulverizing the product. When mixed with sand and water, the powdered and roasted limestone can be used for plaster or for cementing brick together. Mortar made in such kilns was used in 1848 in the construction of Fort Kearney. There is a picnic area at the Smith House.

Exposure 3

From the junction of State Highway 8 and State Highway 15 at the south edge of Fairbury (figure 6), proceed southward for 4.2 miles. Exposure 3 is situated on the left (east) side of Highway 15.

Note the massive, cross-bedded sandstones (figure 7). These are part of the Dakota Group. If you have a small hand lens or magnifying glass (about 10-power), observe the nature of the sand grains making up the rock. Notice that these particles are nearly all angular and approximately the same size (well-sorted). Further, observe that most of the sand grains are composed of the glassy appearing mineral quartz with only a few formed of shiny flakes of mica or a dark mineral (hornblende or magnetite). The spaces between grains are filled with clay. The angular nature of the grains indicates to geologists that the sand has not been transported over a long distance.

Observe the nearly vertical fractures or cracks exposed at several places on the outcrop (shaded in black on figure 7). Such fractures are called "joints." Joints, a common phenomenon in sedimentary rocks, may be produced by a variety of causes such as expansion of material due to removal of weight of overlying rocks, earth movements, freezing and thawing, and local slumping.

Exposure 4

From exposure 3, proceed southward 0.9 mile -- note the clay pit on the east (left) side of the road. (This is on private property -- permission to enter must be obtained from the owners.) Observe from the road that the sandstone forms an escarpment, whereas the shale forms rolling hills. Continue southward for 1.4 miles -- turn east (left) and proceed for 0.2 mile -- the exposure is on the north (left) side of the road (figure 8a).

The rocks at exposure 4 are also ancient stream-channel deposits. Observe the bedding of the sandstone. You can see here both planar bedding and cross-bedding (figure 8b). Such bedding is characteristic of sandbar deposits laid down by a river. Cross-bedding is an arrangement of sedimentary layers that are transverse to bedding planes in straight or concave patterns (figure 8b). Such layers are formed by waves of sand that were deposited, one over another, by either wind or water. Cross-bedding may indicate such stream activities as scour (removal of material) and fill (deposition of material) as well as the active current direction (figure 8b).

Exposure 5

From exposure 4, proceed eastward for 0.6 mile to the "T" intersection -- turn north (left) and proceed for 0.2 mile. The south end of exposure 5 (figure 9a) is to the west (left). Exposure 5 swings westward onto the adjacent private property, curving again eastward so that the north end (figure 9b) is once more exposed on the road 0.1 mile to the north.

Observe the dominance of shale over sandstone at exposure 5. As conditions changed from a near-shore continental environment to a normal marine environment, the channel sandstones gave way to shales. Charophyte fossils (figure 14d) have been found at the south end of exposure 5 (figure 9a). These are the remains of a freshwater alga that could not survive in even brackish water. Such freshwater environments exist in modern deltas forming at the mouths of rivers. In addition to charophytes, some leaf fossils (figures 14c, e, f) and other plant remains have been found at the south end of exposure 5.

At the north end of exposure 5 (figure 9b), you can see several colorful, iron-rich, fine-grained concretionary zones. Observe the brilliant red and yellow as well as the pastel purple and brown iron oxides in some of the concretions. Such minerals

Explanation for Figure 4

A. A stream begins downcutting on a broad, relatively flat expanse of land. The downcutting may result from changes in water supply, gradient, velocity, or base level (usually sea level).

B. As the stream cuts downward, the stream channel shifts back and forth across the valley. There may be numerous episodes of downcutting and channel shifting.

C. By the time the stream has completed its downcutting, it may have scoured a deep and wide valley. When the stream ceases to cut further downward, it may be because of changes in water supply, gradient, velocity, or the base level (usually sea level).

D. The stream now begins to deposit the load of sediment its waters carry. This results in the building of a flood plain (usually silts and clays) and the depositing of channel materials (usually sand and gravel). In addition to the stream deposits on the flood plain, slump and wash from the high valley walls may contribute sediment.

E. The above process continues, gradually filling the valley.

F. Finally the cycle of deposition ceases. The sands are not tightly cemented, forming a narrow and irregularly distributed band in a much larger body of finer grained sediment.

G. A new cycle of erosion begins as the weaker shale is eroded while the more rigid sandstone remains, possibly forming resistant ridges or hills.

H. A sandstone outcrop with shale tongues remains. This may represent any of the "boxed-in" areas in figure 4g.

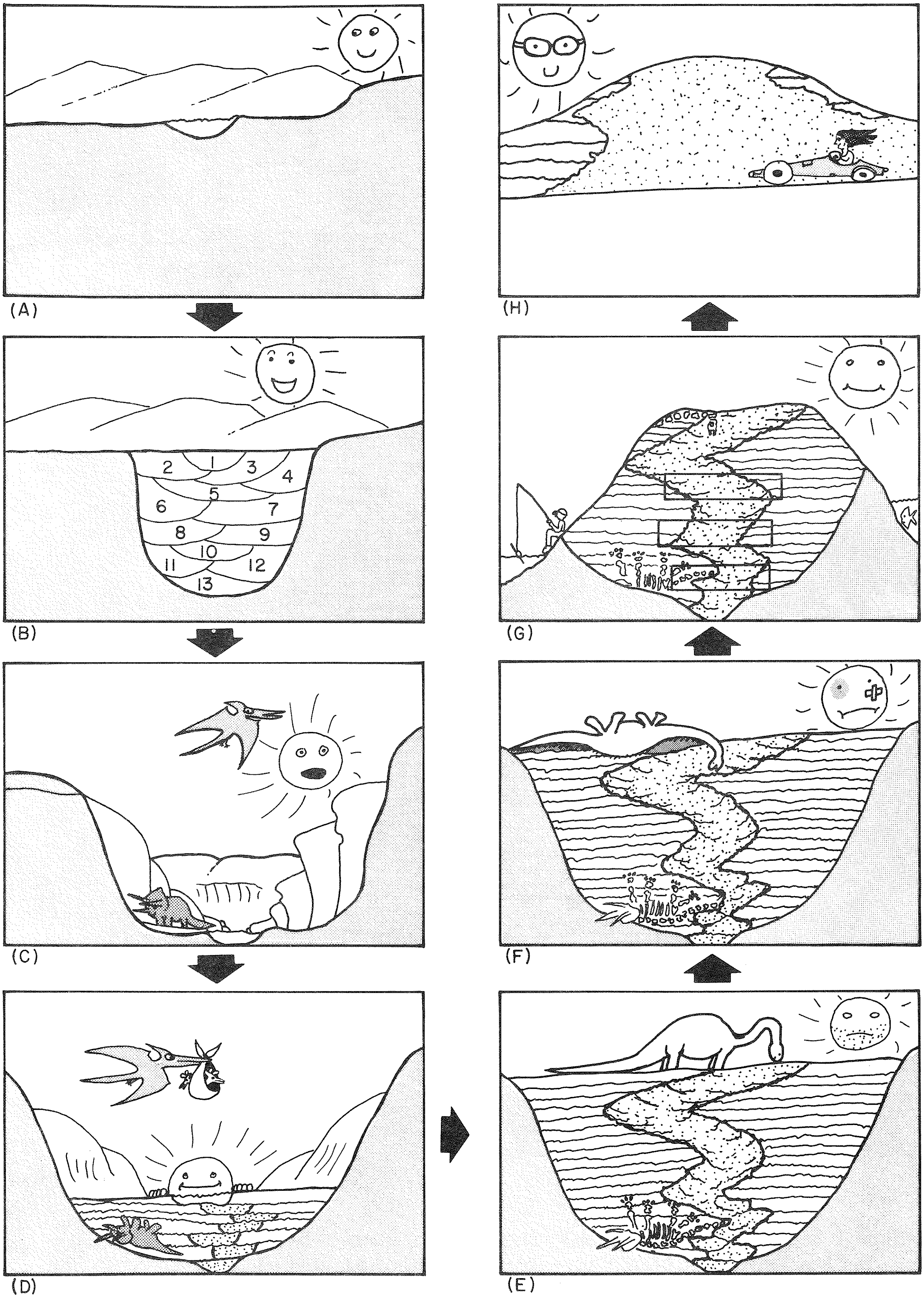


Figure 4.--The history of development of stream channel deposits, as seen at exposure 2. See facing page for explanation of sequence.

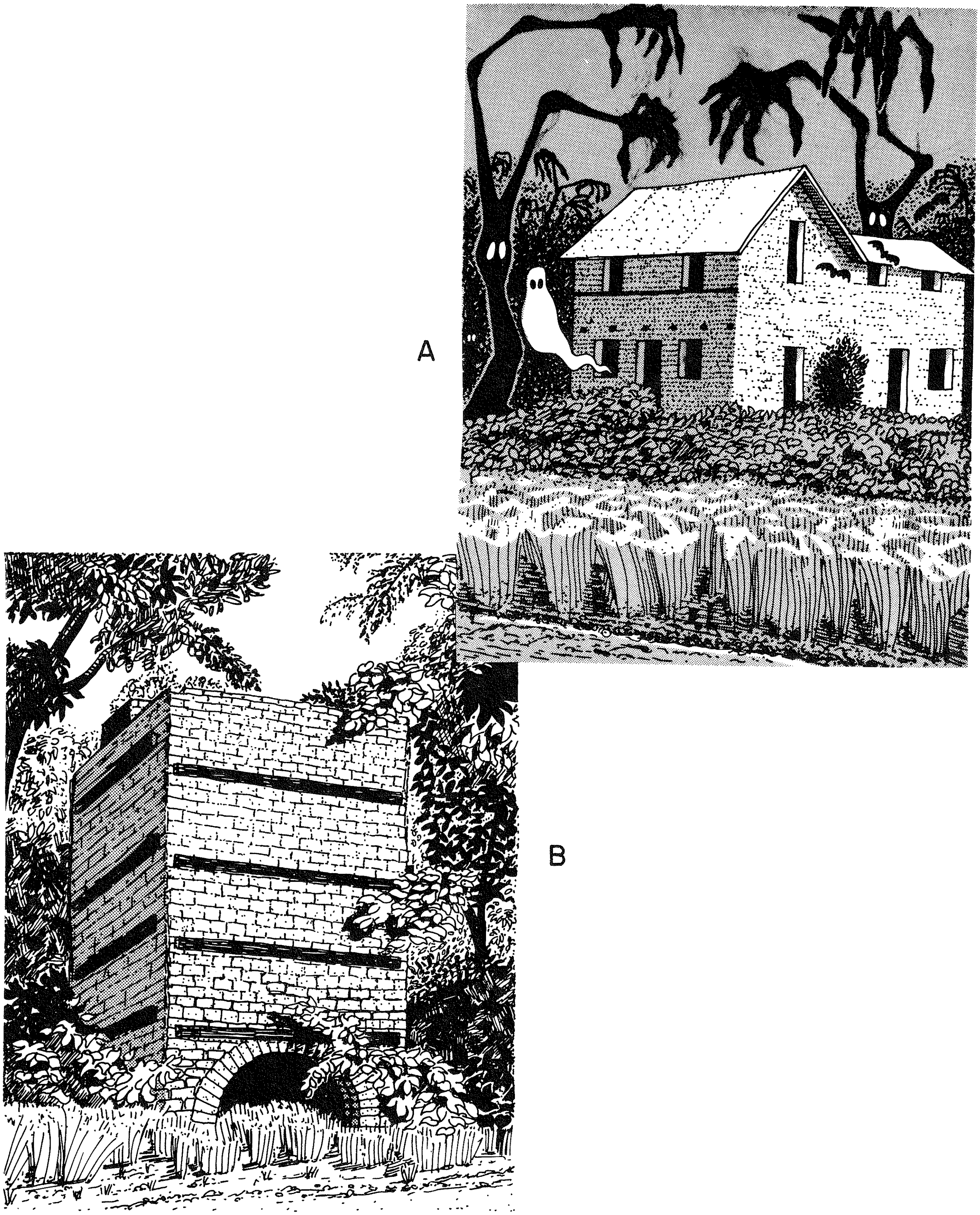
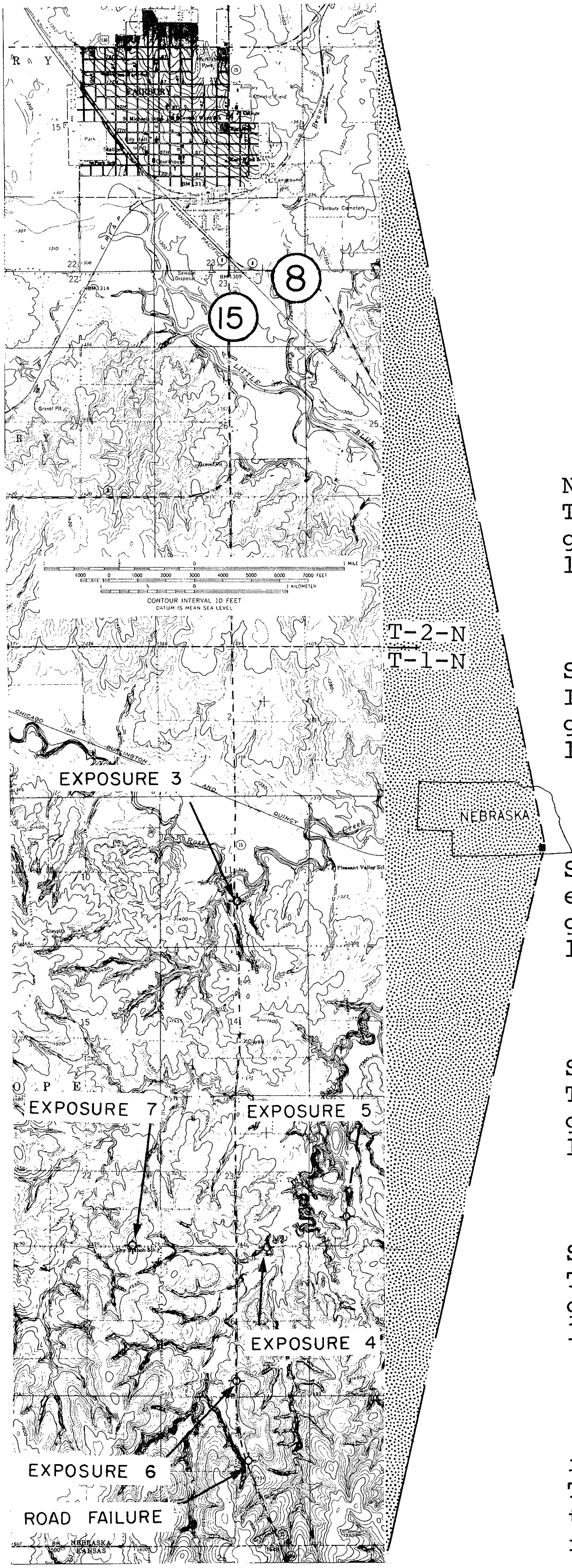


Figure 5.--(A) The Smith House built in 1876 by Woral G. Smith. For additional details of its history, see the adjoining historical marker erected by the Nebraska State Historical Society. (B) The Smith Limekiln built in 1874.



(FAIRBURY SW QUADRANGLE)

LOCATIONS AND ELEVATIONS OF EXPOSURES SOUTH OF FAIRBURY

Figure 6

Exposure 3 is located in the NW ¼, SE ¼, sec. 11, T-1-N, R-2-E. The elevation at the adjacent road grade is 1,330 feet above sea level.

Exposure 4 is located in the SW ¼, SE ¼, sec. 23, T-1-N, R-2-E. Its elevation at the adjacent road grade is 1,400 feet above sea level.

Exposure 5 is located in the SW ¼, sec. 24, T-1-N, R-2-E. The elevation at the adjacent road grade is 1,400 feet above sea level.

Exposure 6 is located in the S ½, S ½, sec. 26, T-1-N, R-2-E. The elevation at the adjacent road grade is 1,550 feet above sea level.

Exposure 7 is located in the SE ¼, SE ¼, sec. 22, T-1-N, R-2-E. The elevation at the adjacent road grade is 1,560 feet above sea level.

The road failure is located in the SW ¼, NE ¼, sec. 35, T-1-N, R-2-E. The elevation at the adjacent road grade is 1,530 feet above sea level.

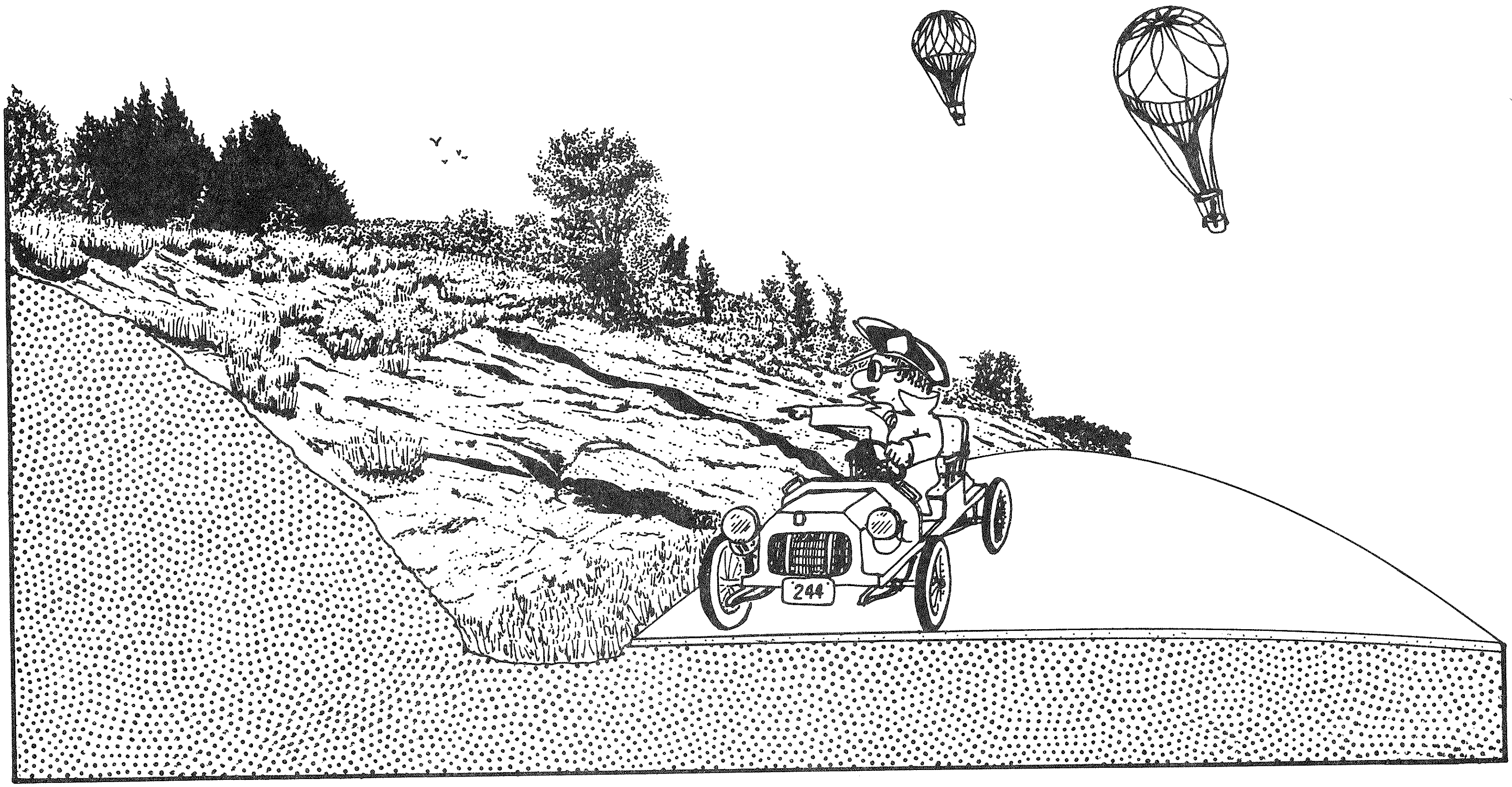


Figure 7.--Idealized section at exposure 3. Note that slumping may alter the appearance of the exposure. View looking south.

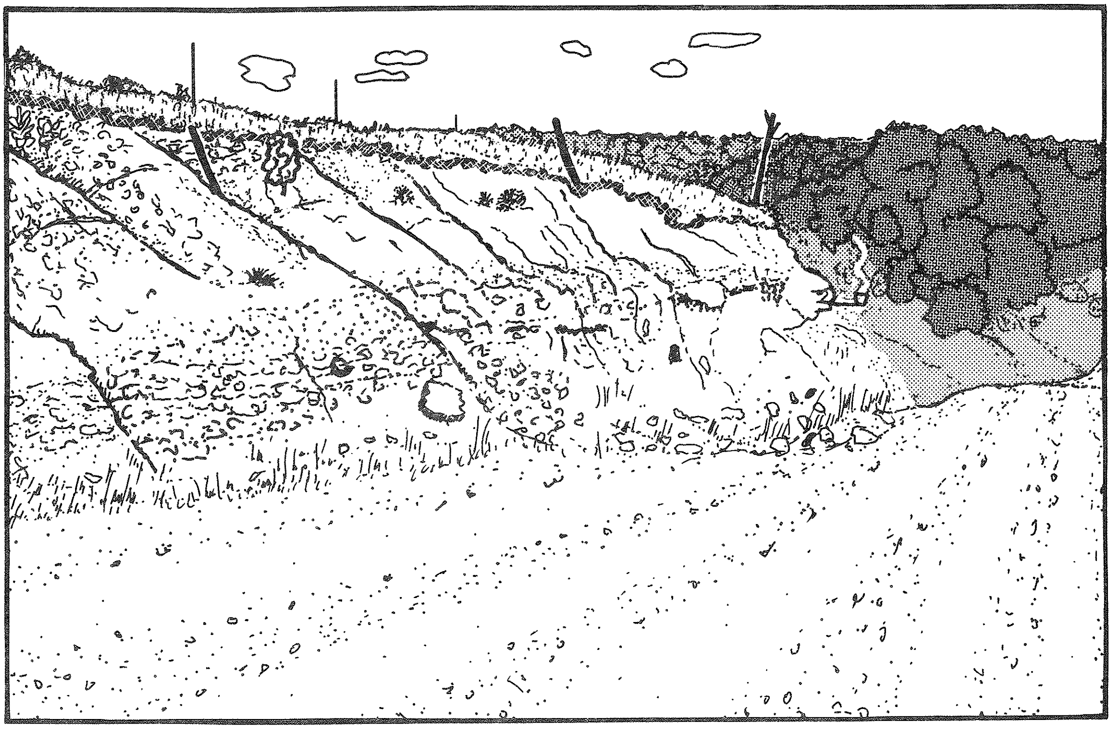


Figure 8a.--Idealized section at exposure 4. Note that slumping may alter the appearance of the exposure.

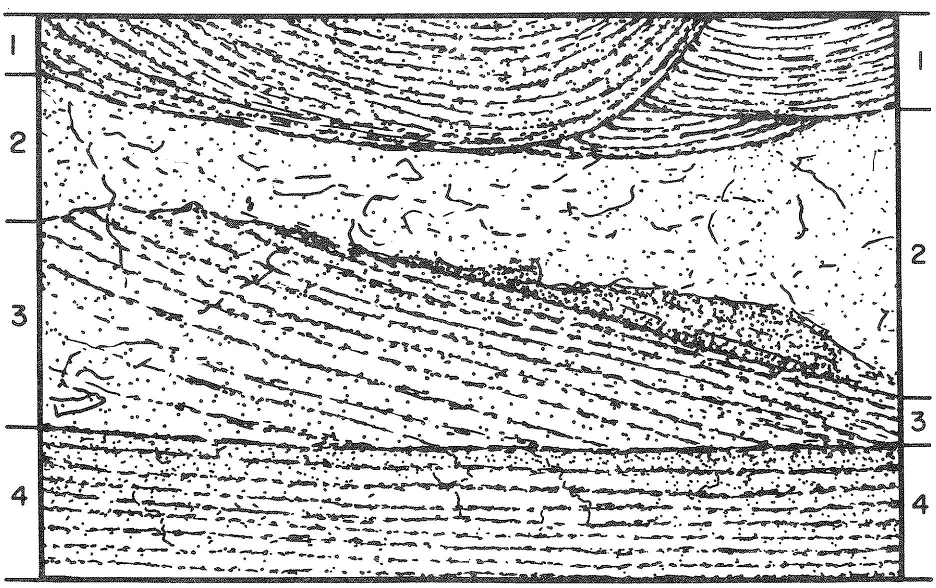


Figure 8b.--Different types of bedding observable at exposure 4, from top to bottom: (1) cross beds showing scour and fill; (2) massive bedding; (3) planar cross beds sloping downstream; and (4) horizontal bedding.

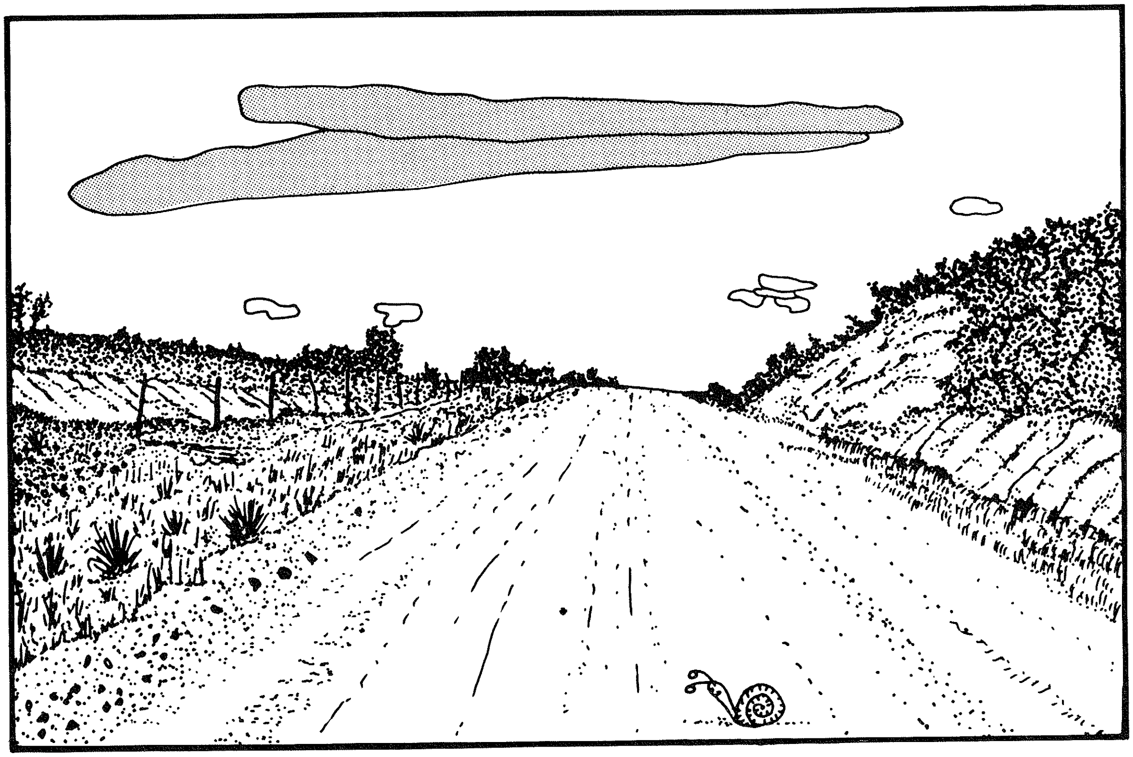


Figure 9a.--Idealized section at the south end of exposure 5. Note that slumping may alter the appearance of the exposure. View looking south.

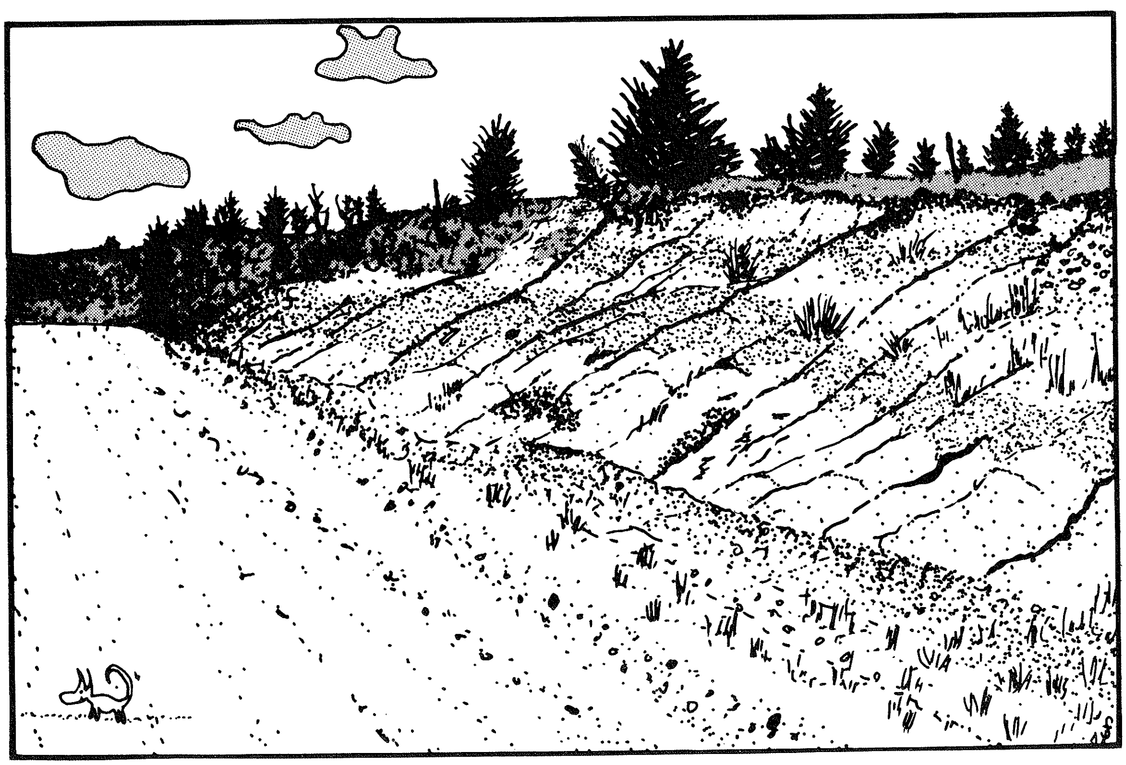


Figure 9b.--Idealized section at the north end of exposure 5. Note that slumping may alter the appearance of the exposure. View looking south.

indicate strong oxidizing conditions, which may have been related to soil development. The American Indians utilized the iron oxides in these concretions as paint pigments, and occasionally even today's artists gather these concretions for the same purposes.

Exposure 6

From exposure 5, return past exposure 4 to Highway 15. Turn south (left) on Highway 15 and proceed for 0.9 mile. Note the exposures on both sides of the road. These exposures of Dakota Sandstone are of particular interest because an "unconformity," or an erosional break in the continuity of deposition of sediments, can be seen here (figure 10). This break may be followed by deposition of a new series of rocks, giving an uneven rather than nearly parallel contact between rock layers.

Observe that the beds at the south end of the exposure are not flat-lying but dip about 24 degrees to the northeast. This gives the impression that the rocks have been tilted upward. Such is probably not the case, for it is likely that these beds were deposited along the side of a stream channel and the dip is depositional rather than structural.

Should future excavations or test drilling show the presence of significant geologic structure in the area, the depositional explanation for the dip of these beds would have to be reconsidered.

Exposure 7

From exposure 6, return northward (toward Fairbury) for 1.0 mile and turn left (west) on the county road. Go west for 0.5 mile, south for 0.25 mile, and west again for 0.2 mile. The exposure is on both sides of the road cut. Here you see the Cretaceous marine deposits of the Graneros Shale-Greenhorn Limestone (figure 11). Observe the great differences in rock type and note that the continental sandstone and shale seen in previous exposures are not visible at the surface. What is visible are younger rocks that were eroded from preexisting exposures. These rocks are largely slabby, horizontally bedded limestones and shales that contain invertebrate fossils such as ammonites and clams.

ROAD FAILURE

An example of the problems encountered in engineering and environmental geology is the road failure 0.5 mile south of exposure 6. See figure 12a.

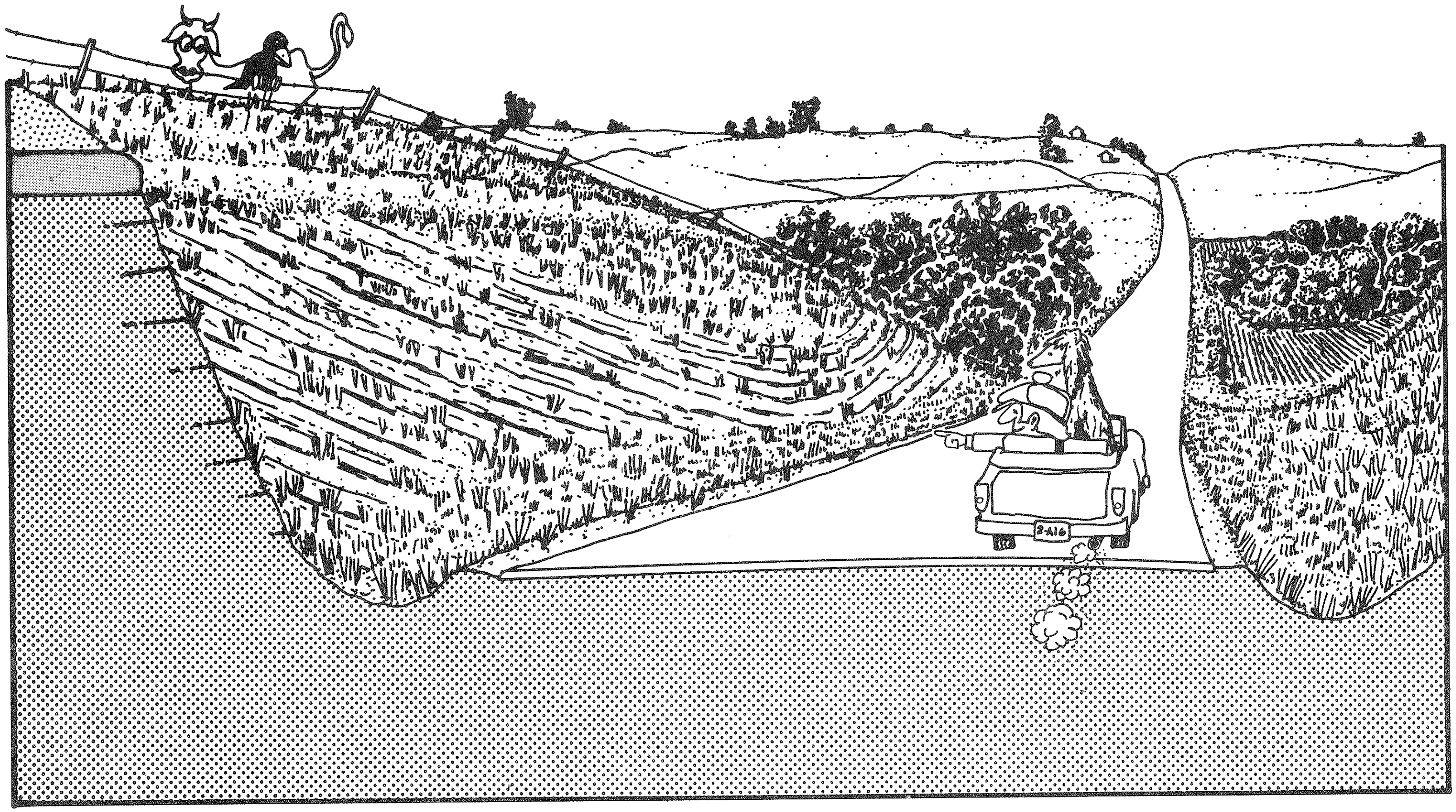


Figure 10.--Idealized section at exposure 6. Note that slumping may alter the appearance of the exposure. View looking north.

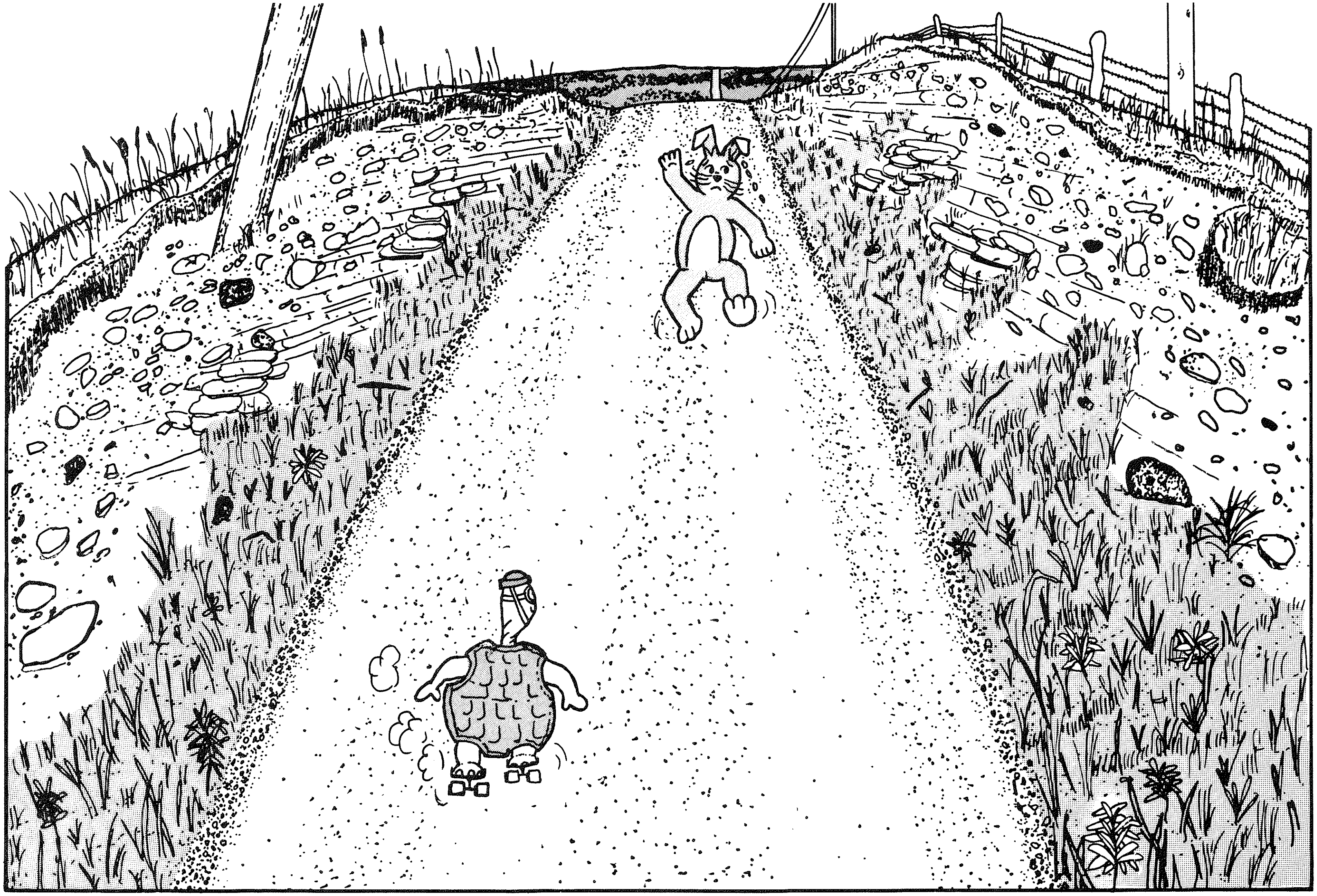
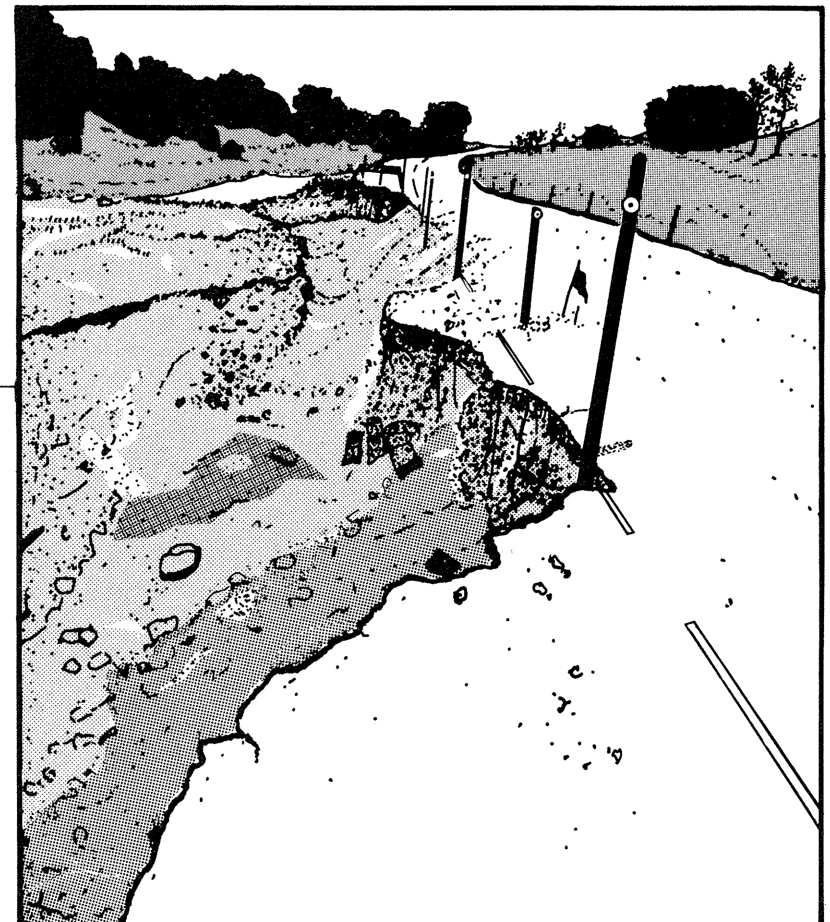


Figure 11.--Idealized section at exposure 7. Note that slumping may alter the appearance of the section. View looking west.

Figure 12a.--A geologically related subgrade and pavement failure near the contact between the Dakota Group (below) and Graneros Shale (above) as it appeared in July 1973. View looking north.



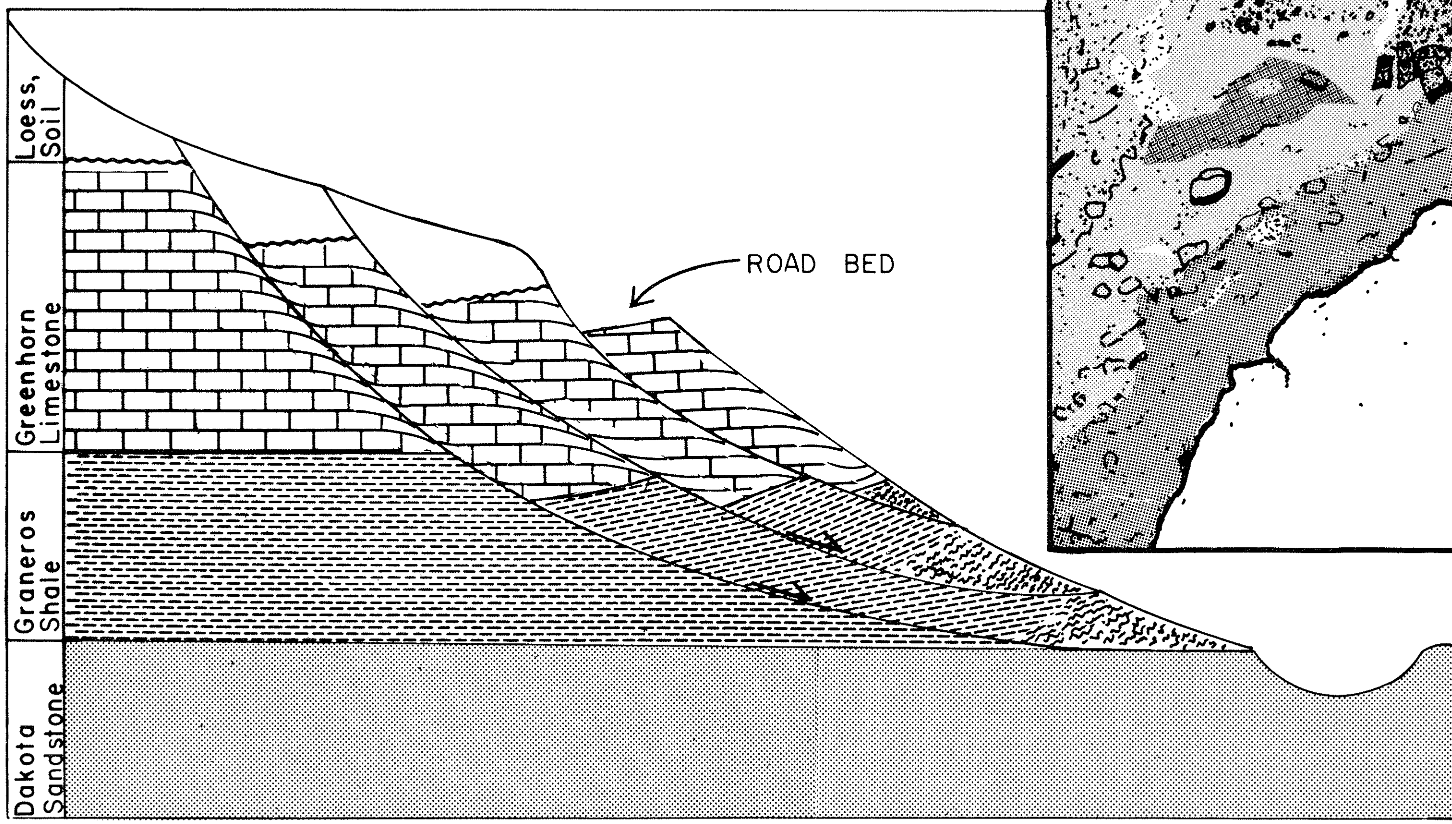


Figure 12b.--East-west cross section of subgrade and pavement failure. Because of road grading, slippage planes accumulate water, which reduces the strength of the rocks. Note that the shale becomes badly crumpled near its contact with the sandstone.

In this area, topographically high outcrops of Greenhorn Limestone are underlain by the Graneros Shale and Dakota Sandstone. There is a deep drainage to the west of the highway and a steep hill to the east. The problem area was recognized before road construction began; however, because of legal problems, the highway department was unable to buy right-of-way in areas to the west or east. It was known that a series of quite large slip or slump planes (400-500 feet) was present in the area (figure 12b). These slip planes allow large blocks of material to slide downhill toward the creek. The road was completed in 1950, and by 1955 the slip planes started opening on the west side of the hill and across the highway. Evidence of recent movement is quite obvious near the creek where very large trees have been uprooted. Even trees on the hillside are tilted due to the unstable slope.

Because of the slip planes, large quantities of water can infiltrate the Greenhorn Limestone and Graneros Shale, both of which have open fractures. When the clays within these units absorb water, the strength of the rock is reduced. Normally this is a slow process; however, grading the roadbed exposed the fractured rocks and provided an avenue for water to percolate into the underlying limestone and shale instead of running off the side of the hill. As would be expected, this has increased the rate of slippage.

CONCLUSION

Most of the rocks of the Cretaceous Dakota Group consist of claystones and shales as seen at exposures 1 and 5. Sandstones, however, are more resistant to weathering and erosion, and so are more likely to form outcrops. Sedimentary features and fossils provide the most important means for interpreting the depositional environment of Dakota rocks. Most Dakota rocks were deposited as deltas by river systems at or near the margin of a shallow sea. The various environments of deposition for each of the exposures studied are shown in figure 13.

The plant fossils in Dakota rocks include both upland and lowland forms. In some areas the excellent preservation of plant remains (exposure 5) indicates they have not been transported very far; whereas in other areas (exposure 1), the plant remains are badly broken up and form peat layers. The shales at exposure 5 contain charophyte fossils, the remains of a freshwater alga. Charophytes cannot live even in slightly brackish water. In addition to freshwater charophytes found at exposure 5, specimens of the brackish-water clam, *Brachidontes* (figure 14g), have been found at the Endicott Clay Products pit, which is on private property south of Fairbury. A few reptilian fossils have been recovered to the south in Kansas. Marine and brackish-water mollusks are known from other sections of Dakota rocks in Kansas.

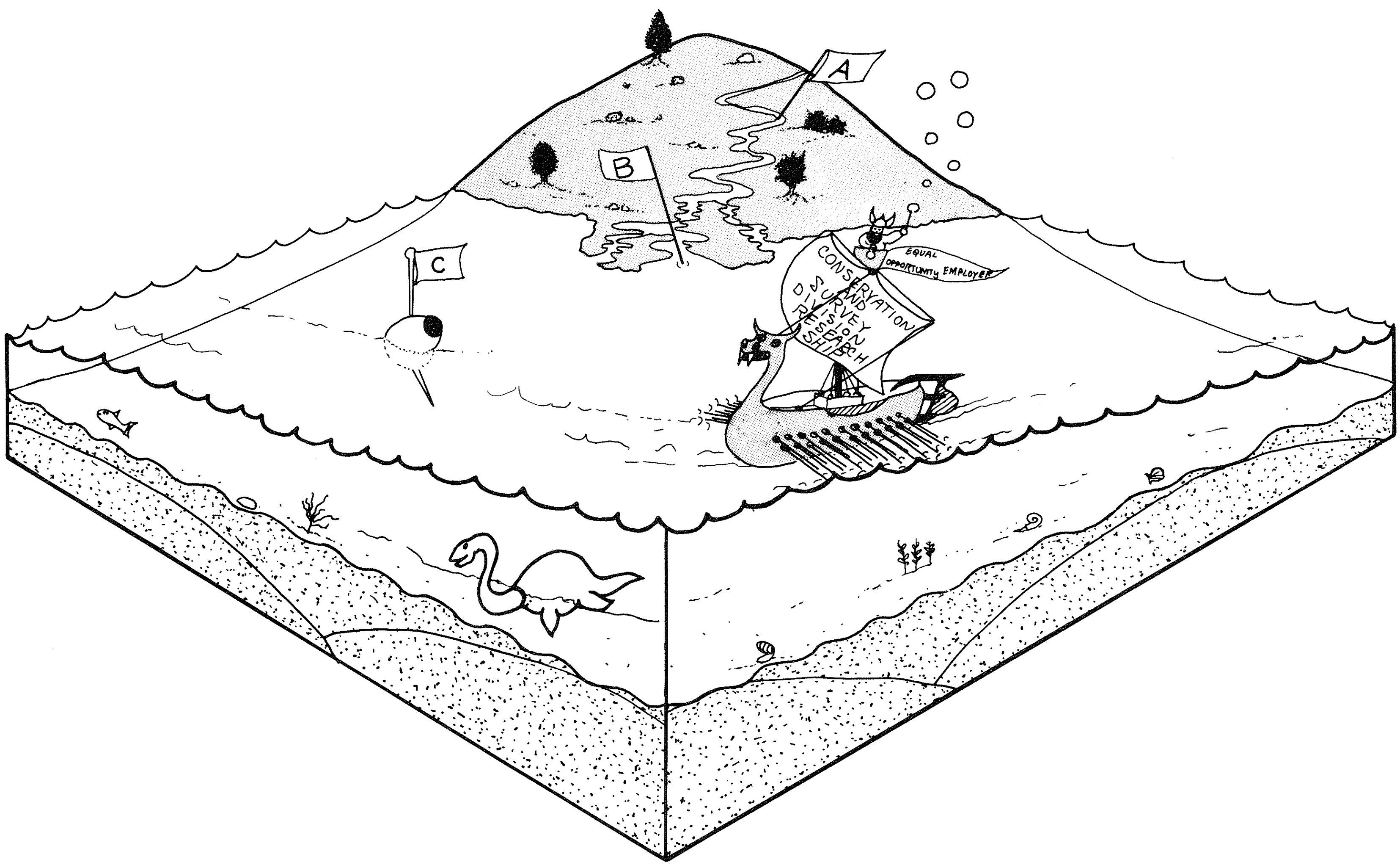


Figure 13.--Environments of deposition visible in the Fairbury area: (A) stream-channel deposits (such as sandstones), exposures 2, 3, 4, and 6. (B) delta-front deposits (such as siltstones and claystones), exposures 1, 4, and 5. (C) Open-marine deposits (such as shales and limestones), exposure 7.

Such fossil occurrences strongly suggest a deltaic front environment situated near a normal marine environment. To the west (exposure 7), we see limestones and shales (of a slightly younger age) that contain normal marine fossils such as bivalves, oysters, and ammonites, which indicate an advancing sea.

For further comparison and study, the student wishing to view Cretaceous open-marine deposits may do so by consulting the Thayer County-Gilead-Alexandria Area Field Guide.

SOME COMMON ROCKS AND FOSSILS
YOU MAY FIND DURING YOUR TRIP

Figure 14

A,B - Sandstone concretions, X 1.

C - Tree leaf, *Sassafras*, X 1.

D - Charophyte egg case, X 60.

E - Fern leaves, genus and species undetermined, X 3.

F - Tree leaf, *Ficus*, X 1.

G - Freshwater clam, *Brachidontes*, X 1.

H - Marine clam, *Inoceramus*, X 1.

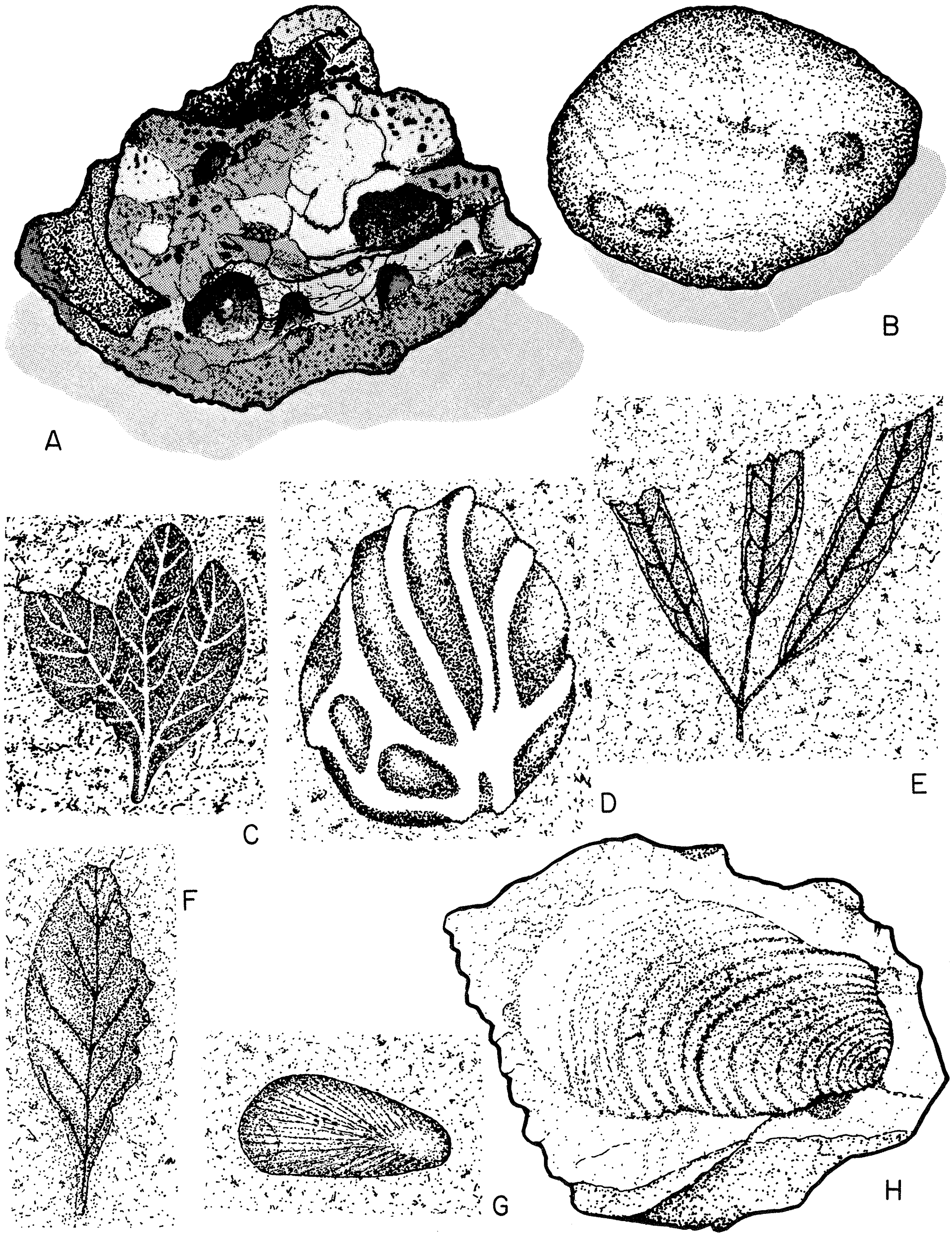


Figure 14

Some Additional Publications Available from the Conservation and Survey Division

RECORD IN ROCK, A Handbook of the Invertebrate Fossils of Nebraska: *Roger K. Pabian,* Educational Circular No. 1 (1970).

MINERALS AND GEMSTONES OF NEBRASKA, A Handbook for Students and Collectors: *Roger K. Pabian,* Educational Circular No. 2 (1971).

SOILS OF NEBRASKA: *J. A. Elder,* Resource Report No. 2 (1969).

DIRECTORY OF NEBRASKA QUARRIES, PITS, AND MINES: *R. R. Burchett,* Resource Report No. 5 (1971).

CENTENNIAL GUIDEBOOK TO THE GEOLOGY OF NEBRASKA: *R. R. Burchett and E. C. Reed* (1967).

GUIDEBOOK TO THE GEOLOGY ALONG THE MISSOURI RIVER BLUFFS OF SOUTHEASTERN NEBRASKA AND ADJACENT AREAS: *R. R. Burchett* (1970).

GUIDEBOOK TO THE GEOLOGY ALONG PORTIONS OF THE LOWER PLATTE RIVER VALLEY AND WEEPING WATER VALLEY OF EASTERN NEBRASKA: *R. R. Burchett* (1971).

THE GEOLOGICAL SECTION OF NEBRASKA: *G. E. Condra and E. C. Reed,* Nebraska Geological Survey Bulletin No. 14A (1943, revised 1959).

REVISION OF THE CLASSIFICATION OF THE PLEISTOCENE DEPOSITS OF NEBRASKA: *E. C. Reed and V. H. Dreeszen,* Nebraska Geological Survey Bulletin No. 23 (1965).

GEOLOGICAL MAP OF NEBRASKA: Compiled by *R. R. Burchett,* 1:1,000,000 Scale (1969).

TOPOGRAPHIC MAPS: Topographic Map Division, U.S. Geological Survey.

AGE (MILLIONS OF YEARS AGO)	GEOLOGIC TIME UNITS		ROCK TYPES	MINERAL RESOURCES AND PRODUCTS	TYPICAL FOSSILS
2	CENOZOIC (RECENT LIFE)	PLEISTOCENE	Glacial till, silt, clay, sand, gravel, volcanic ash.	Agricultural soil, water, sand & gravel, volcanic ash.	MAMMALS
70		TERTIARY	Sandstone, siltstone, clay, gravel, marl, volcanic ash.	Agricultural soil, water, sand & gravel, volcanic ash, riprap.	
135	MESOZOIC (MIDDLE LIFE)	CRETACEOUS	Chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate	Water, oil & gas, cement, brick, agricultural lime, & other construction materials.	REPTILES
180		JURASSIC	Subsurface only. Sandstones and shales		
225		TRIASSIC			
280	PALEOZOIC (ANCIENT LIFE)	PERMIAN	Shale, limestone, dolomite, gypsum, anhydrite, sandstone, siltstone, chert.	Water, agricultural lime, oil, road rock, riprap.	AMPHIBIANS
310		PENNSYLVANIAN	Limestone, shale, sandstone, coal.	Oil, cement, brick, concrete aggregate, lightweight aggregate, road rock, agricultural lime, rip rap, water.	
350		MISSISSIPPIAN	Subsurface only. Limestone, dolomite.	Oil, water.	FISH
400		DEVONIAN	Subsurface only. Dolomite, gray shale.		
440		SILURIAN	Subsurface only. Dolomite.		INVERTEBRATES
500		ORDOVICIAN	Subsurface only. Dolomite, sandstone, shale.		
600		CAMBRIAN	Subsurface only. Dolomite, sandstone.		
5,000 / ?	CRYPTOZOIC (HIDDEN LIFE)	PRECAMBRIAN	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.		?

FG-7 $1.00